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Higher prices, lower costs give better outlook for profits
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CHEMICAL & ENGINEERING
NEWS
OCTOBER 14, 1991

News of the Week

■ **German scientists Erwin Neher and Bert Sakmann win 1991 Nobel Prize in physiology or medicine for their discovery of ion channels and how they enable cells to communicate.** Page 4

■ **Supreme Court refuses to hear suit by Genetics Institute against Amgen over U.S. market rights to erythropoietin, lets stand appeals court decision that benefits Amgen.** Page 5

■ **Energy Department draws fire for bypassing Congress in move to start testing underground nuclear waste repository in New Mexico.** Page 5

■ **First use of gene therapy to immunize cancer patients against their own tumors began last week at NIH.** Page 6

■ **Two prominent scientists—Caltech's Leroy Hood and Rockefeller's Gerald Edelman—will relocate with their labs.** Page 6

Cover: Photo by T. Stephan Thompson/Uniphoto Picture Agency

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Business

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Science/Technology

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ACS News

National Chemistry Week '91, scheduled for Nov. 3 to 9, is shaping up to be as colorful and creative as previous years' events. **Page 60**

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Product Report

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LETTERS

Voltammetric pH sensing

This is in reference to our recent report entitled "Molecular Self-Assembly of Two-Terminal Voltammetric Microsensors with Internal Reference" [*Science*, 252, 688 (1991)] that was featured in Ron Dagani's Science/Technology article (C&EN, May 27, page 24). We wish to point out the earlier conception of voltammetric pH sensing based on the peak potential difference between two electrode-confined redox couples by Israel Rubinstein [*Anal. Chem.*, 56, 1135 (1984)]. We appreciate Rubinstein's bringing this to our attention.

Mark S. Wrighton
Professor of Chemistry
Massachusetts Institute of Technology
George M. Whitesides
Professor of Chemistry
Harvard University

Chemical distributors

The article "Chemical Distributors Expand Services To Meet Industry Pressure" (C&EN, July 29, page 25) does an excellent job in exploring a host of issues, opportunities, and challenges confronting chemical distributors and the chemical industry.

However, I want to comment on the remarks you quote of a chemical company distributor manager, who asked not to be named, regarding the Responsible Distribution Process the National Association of Chemical Distributors (NACD) is developing for its more than 250 chemical distributor member companies.

NACD developed its own Responsible Distribution Process, rather than signing on to the Chemical Manufacturers Association's Responsible Care initiative, for two important reasons: Our members believed they could not make a commitment to code provisions over which they had no control or which did not apply to them; and the CMA Distribution Code is written for manufacturing distribution and transporters. It is largely nonspecific to chemical distributors.

Wherever and whenever possible, the language of the CMA codes is picked up verbatim in the NACD Responsible Distribution Process. NACD's code-writing committee studied the CMA Distribution Code and applicable portions of its other codes long and hard trying to make a fit before recommending our own Responsible Distribution Process.

In every sense Responsible Distribution will be a stretching process for our chemical distributor members. It will also be more expensive, and for some members with limited resources it may be difficult. NACD is prepared to assist companies with compliance and is writing an implementation guide for this purpose.

The only way Responsible Distribution will make life easier than Responsible Care for distributors is that it covers functions specific to distribution that are not manufacturing functions and are not covered in the CMA codes. In that sense it will be less confusing and frustrating.

NACD certainly wants full and open discussion and constructive criticism of its Responsible Distribution Process.

James M. Doyle
President
National Association of Chemical Distributors, Washington, D.C.

Reformulating gasolines

The negotiated regulatory agreement on reformulated gasoline among various environmental interests, state and local air regulatory agencies, the oil industry, ethanol and methyl *tert*-butyl ether (MTBE) advocates, and the Environmental Protection Agency (C&EN, Aug. 26, page 4) may well prove to be a faustian bargain for all involved. General Motors, Congress, and the Bush Administration also must share blame for mandating the ill-advised use of oxygenates in gasoline as a preferred means of cleaning up our nation's carbon monoxide and ozone air pollution problem areas. The public, its health and economic welfare, will suffer.

The only part of this bargain that will have irrefutable public health and economic benefits is requiring reductions in

Correction

• Sept. 30, page 68: In the Southeast Regional Meeting program, the correct times for Wednesday morning's organic chemistry papers are: no. 228, 8:30; no. 229, 9:20; no. 230, 10:10; and no. 231, 11:00.

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Chemical industry to face increasing challenges in 1990s

Earl V. Anderson,
C&EN Northeast News Bureau

More rapid evolution, ever more "globalization," competition for capital, new technology, and work force—these are only a few of the challenges that lie ahead for the chemical industry as it works its way through the final decade of the 20th century.

During a recent meeting of the Chemical Management & Resources Association at White Sulphur Springs, W.Va., several industry experts jointly painted a vivid picture of what the industry is likely to face in what they call the "new world order." Anchoring the crystal ball was

Exxon Chemical's most recent assessment of the industry's long-term outlook—to the year 2000.

Exxon is convinced the chemical industry will undergo a lot of structural change in the 1990s. Some of these changes will occur at the interface between refining and petrochemical operations, says Jean-Francois Berthiaux, an Exxon Chemical vice president.

High on the list of these changes is the reformulation of gasoline, driven by the Clean Air Act. This act requires a minimum oxygen content in gasoline, sets emission standards, and imposes additional restraints that are certain to have an impact on benzene and butane.

The impact of these requirements is compounded by a strong push toward high-efficiency and low-emission vehicles. And the resulting changes in motor fuel, together with a shrinking gasoline market, will significantly affect petroleum economics and operations. That, says Berthiaux, leads to "tremendous" implications for the refinery-chemical plant interface.

The value and availability of various refinery streams will change. The impact will be felt in the supply-demand balance for important

C&EN staff photos

Berthiaux (left), Orr: corporate aim—think globally, act locally

chemical feedstocks, such as propylene, isobutane, and aromatics. It is also likely there will be fewer—and smaller—refineries.

The survivors, says Berthiaux, will be very efficient. They will have little spare capacity and very few low-value by-product streams available for chemical upgrading. In fact, he says, refining operations, such as reforming and catalytic cracking, that are very important for chemical operations today, may find that their primary roles in the future will be the "on purpose" production of chemical feedstocks.

However, all is not bleak. Opportunities for new chemical products will open up in the changing transportation and fuel markets. But integrated companies, says Berthiaux, will be in the best position to capitalize on them.

Exxon also believes the gap between petrochemical companies and "traditional" chemical companies will widen. Traditional chemical companies will continue to move away from building-block petrochemicals and their large-volume derivatives. They will intensify their focus on consumer products, advanced materials, pharmaceuticals, biotechnology, and electronics. They will look even more like multitechnology conglomerates than they do today, says Berthiaux.

On the other hand, the successful integrated petrochemical companies will have for parents oil companies that will play a stronger role in the goals, strategies, and priorities of their petrochemical divisions. The mission of petrochemical companies will be to upgrade petroleum feedstock to the maximum. For traditional chemical companies, creating value-added products will be the name of the game.

According to Berthiaux, petrochemical companies will emphasize process technology; chemical companies will put a premium on product technology. As growth slows and competition intensifies during the nineties, all companies will realign their product lines and focus on what they do best.

The industry will continue to be driven by technology, just as it always has been. However, in the product arena, industry leaders will be putting more emphasis on applications and problem solving. In the process field, they will shift to completely new frontiers.

Process technology, for instance, will shift from incremental improvements to totally different approaches—for example, alternate feedstocks to produce derivatives directly and new basic processes, such as separations and selective catalysis. The chemical industry's penchant for innovation shows no sign of letting up, says Berthiaux.

Polyolefins will become more important and a "polyolefins materials industry" will emerge, according to the Exxon analysis. Exxon believes

polyolefins will continue to penetrate markets at the expense of other materials.

New catalyst and reactor technologies will produce new olefin monomers and comonomers that will compete with higher priced, high-performance engineering plastics. Single-site catalysts, for instance, may produce these polyolefins for $1.00 per pound or less, Berthiaux says.

Total demand for the chemical industry's products will continue to grow, but that growth will vary by region and by product, he says. "We still see the highest growth rates in the Asia-Pacific region." Demand in North America and Europe will more or less follow gross national product.

However, traditional export markets will disappear because of worldwide overcapacity, putting a crimp in production rates. Olefins is just one example. Philippe Michelon, vice president of SRI International, says the share of olefins capacity held by "new" producers (those outside the U.S., Europe, and Japan) will increase from 24% this past year to 32% in 1997. By the year 2000, he adds, there will be 28 more ethylene producers than there were in 1990.

Increasing pressure to reduce consumption, reuse, reformulate, and recycle could make the market outlook even worse. However, Berthiaux notes the chemical industry always has been able to develop new solutions to problems and to create new products.

Intense competition will mean prolonged periods of low profits in this decade, he adds. Only the largest or second largest companies in each market segment will enjoy a competitive advantage.

Alliances and acquisitions will become increasingly important for chemical companies, according to the analysis. The current industry mind-set leans toward greater emphasis on core businesses. In the upcoming period of slower growth and lower profits, many companies will divest noncore lines and either buy or swap for assets that they need to strengthen their core businesses.

Exxon believes the acquisition wave of the 1980s will continue because companies will see it as a low-cost way to reach their goals without starting from scratch. The number of alliances between chemical companies will rise, as they realize that they can't afford to duplicate existing capabilities. Alliances will provide an inexpensive way to gain new technology and a toehold in markets.

But competition for capital will intensify during the decade, says Berthiaux, as more and more demand falls upon a limited supply. Money will be tight and capital will become more expensive.

It is expected the chemical industry will have to bear a disproportionate share of this cost because of its large environmental expenditures. It also will have to find alternative ways to finance its projects.

European and Japanese companies, as well as those in the U.S., will attempt to diversify geographically. The key will be to leverage their regional competitive advantages on a worldwide basis.

Companies must learn to "think globally, but act locally," says Berthiaux. There's no ideal model, but he cites setting corporate goals and strategies and developing technology as tasks that should be managed centrally. Operations should be managed at the local level.

Coincidentally, Donald J. Orr, senior vice president for chemicals at Air Products & Chemicals, offers the same advice—"think globally, act locally." Orr says day-to-day business or technical decisions for any foreign market can't be made "while sitting many thousands of miles, multiple time zones, and unique cultures away from the action."

Air Products practices what Orr preaches. More than 25% of its sales are outside the U.S. and its goal is 40% in five years.

Although it produces industrial gases in 25 countries, the company produces chemicals in only three countries outside the U.S. However, Air Products provides both technical service and applications R&D locally. Of the 4000 employees the company has outside the U.S., fewer than 40 are Americans. "We are also very comfortable with joint ventures with local partners," says Orr. Air Products has 10 such ventures in Southeast Asia alone.

Closer to home, one of the most important challenges facing the industry in the 1990s—and beyond—is attracting and retaining the best people. Berthiaux says chemical companies will have a tough job doing so, because they must compete against industries that are perceived to be more "environmentally friendly."

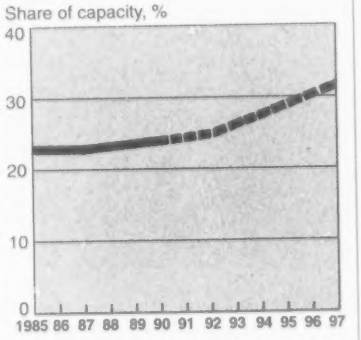
An even bigger problem, says J. Kermit Campbell, Dow Corning's group vice president of U.S. operations, is developing a "world-class" work force out of this country's inadequate educational system. Education at the primary and secondary levels must be reformed, says Campbell.

Math and science achievement levels lag those in many other countries. "That's a tragedy in a technology-driven age," Campbell says. And many students cannot even read or write. That, he adds, is a tragedy in an evolving information age. □

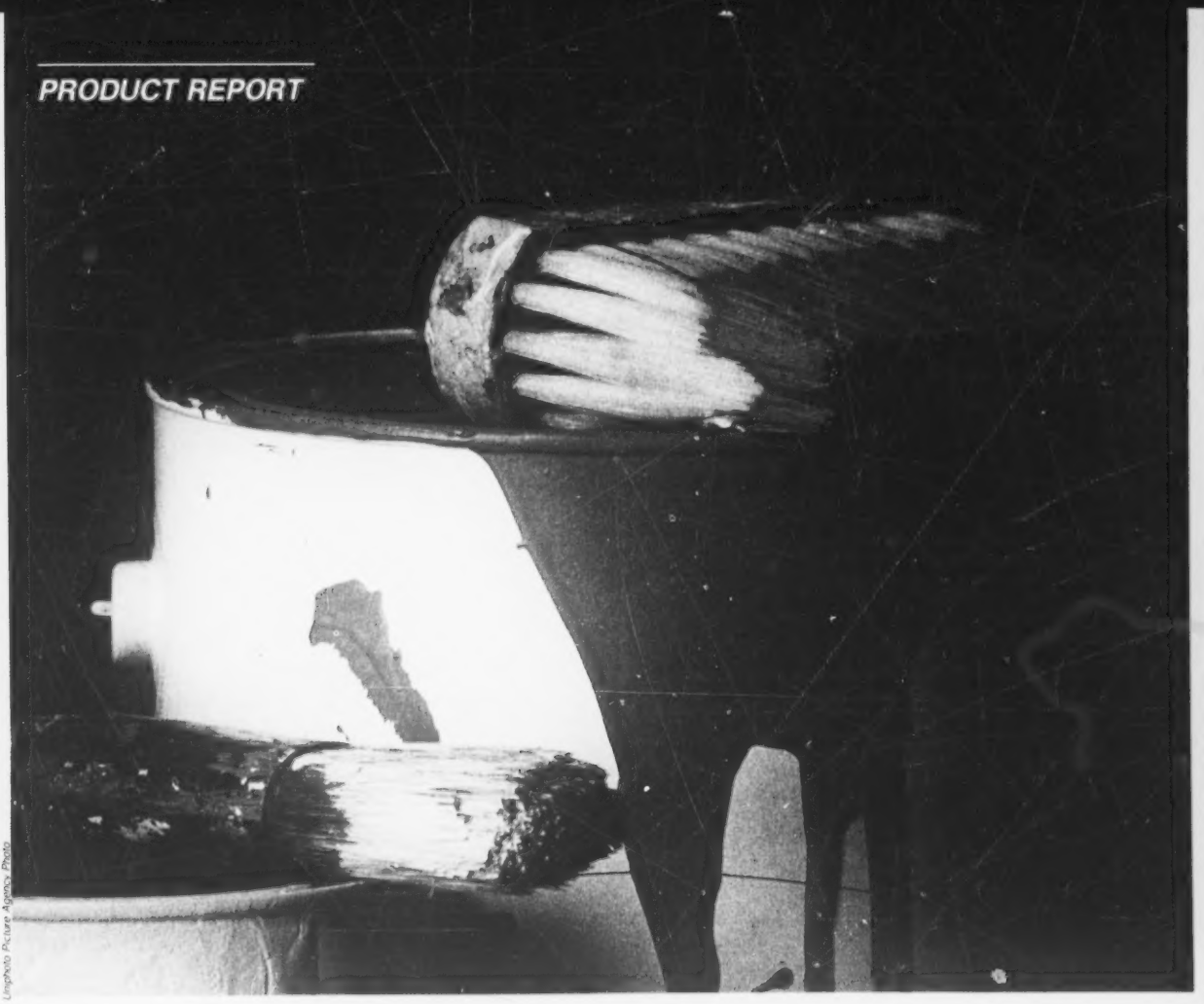
By 2000, an excess of ethylene producers . . .

	Number of producers		
	1990	2000	% change
Far East (except Japan)	19	36	17%
North America	22	25	3
South & Central America	14	17	3
Africa	3	5	2
Japan	12	13	1
Western Europe	24	24	0
Eastern Europe	9	9	0
Middle East	7	7	0
Oceania	3	3	0
WORLD	113	139	28%

. . . and a big capacity gain for new olefin producers



Note: Olefin producers outside the U.S., Europe, and Japan. Excludes Eastern Europe and China.
Source: SRI International



LingPhoto Picture Agency Photo

Higher Paint Sales Brighten Profits Outlook

Marc S. Reisch,
C&EN Northeast News Bureau

Paint makers received a record value for their shipments last year, $11.6 billion, although the total volume of shipments declined more than 6% for the second year in a row to 1 billion gal.

Government statistics show that the value of shipments and cost per gallon of paint sold increased in the three categories into which the government separates data: architectural, product, and special-purpose coatings. Actual shipment volume, however, declined in the largest category, architectural coatings, as well as in the second largest, product coatings.

Manufacturers of radiation-curable coatings—the focus of this year's article—offer their products as a way to eliminate or reduce emissions of volatile organic compounds (VOCs). Moreover, these coatings offer rapid cure on high-speed coating lines.

But whereas radiation-curable coatings are ideally suited for use on production lines, coating of large structures like bridges and large storage tanks in place will not benefit from electron beam and ultraviolet radiation-initiated curing technology. In these cases, uniform exposure to radiation sources is difficult to achieve. However, the inclusion of an aliphatic isocyanate along with an appropriate polyol to create light-stable and chemical-resistant coatings do frequently offer performance advantages. Olin and Hüls plan new U.S. production units and, along with long-time producer Mobay (soon to change its name to Miles), which recently has expanded capacity, these producers may significantly accelerate the growth in aliphatic isocyanate-containing coatings.

As word gets out about the performance advantages of aliphatic isocy-

anate coatings, existing manufacturers of aromatic isocyanate coatings also may see some growth in the use of their products. This may be true especially when direct exposure to weathering elements is not a factor but when the toughness and chemical resistance that these isocyanates give coatings offer major benefits.

Other factors also will affect the maintenance-coatings market, such as the cost of isocyanate-containing systems versus other maintenance paint formulations, as well as concerns about the health of workers applying isocyanate-containing coatings. As a result, other coating systems are being refined for the maintenance of steel and other industrial structures.

Shipments declined 6% last year

The Persian Gulf War put the brakes on a slowing U.S. economy last year and the paint industry went into a skid. The recession, though, has had some beneficial effects. Raw material costs moderated, and paint companies further cut the cost of doing business by paring back on their payrolls. The breakup of the well-known paint maker DeSoto was largely completed last year (C&EN, Sept. 17, 1990, page 40) and so some of the huge business realignments that occurred during 1990 have not troubled the industry as it attempts to shake off the recession in 1991.

Last year, however, was not a good year for paint shipments. U.S. paint makers shipped just a little more than 1 billion gal of paints and coatings in 1990, down more than 6% from the previous year, according to the most recent data from the Department of Commerce. The result was that industry shipments were almost as low as they were in 1986 when the industry shipped just 987 million gal.

However, the value of industry shipments last year rose 2.5% from 1989 to $11.6 billion. As shipments slipped and prices increased, the average price per gal of paint rose 9.3% to $11.58 in 1990. Manufacturers were able to increase prices at rates greater than the 5.5% rate of inflation for the year. Those increases helped manufacturers in part to recover the increasing costs of raw materials. According to the Department of Commerce, paint material prices in 1990 increased 5.6% from 1989. In 1989, raw material costs rose nearly 12% from the previous year, and the price of paint per gallon rose only 10% to $10.58.

Preliminary 1991 data indicate that paint material costs have moderated even further. Manufacturers report an abundance of titanium dioxide, a key pigment in paints, as new capacity comes on line. The Department of Labor's index of raw material costs indicates that paint material prices actually have decreased nearly 11% between January and August of this year. So the current recession has at least brought the paint industry the benefit of lower raw material costs.

The decline in the cost of raw materials also has given paint formulators some breathing space in the costs they must bear and eventually recover as they formulate their paints to meet increasingly stringent government regulations affecting the emissions of VOCs. As traditional liquid paint formulations dry, organic solvents, which make the paint flow for application, evaporate and can be a component in the formation of atmospheric smog. Paint formulators have had to assume the costs of reformulating their paints or developing new technologies such as powder coatings or radiation-curable coatings to satisfy government limits on VOC emissions that in some categories are as low as 2.8 lb per gal.

Given the available industry statistics, it is difficult to get a solid fix on the profitability of this very large, mature, and diverse industry. For one thing, a significant number of paint operations are themselves part of larger companies, such as Du Pont, BASF, and PPG Industries. The industry also includes a number of large independents, like Sherwin Williams and Valspar, and then a host of small- and medium-sized paint and coatings companies.

The Rauch Guide to the U.S. Paint Industry, produced by Rauch Associates in Bridgewater, N.J., estimates there are 1065 paint companies operating in the U.S. today, 45% of which have fewer than 20 employees. Rauch has the most solid data on industry profitability, but the data are three years old and date from a period when shipments and values grew significantly, raw material price increases were modest, and employment was on the rise. Rauch cites Internal Revenue Service data for 1987–88 from 840 paint and allied products companies reporting total receipts of $10.1 billion and net income of $572 million. These companies' combined profit margin was 5.6% and return on equity 23.2%.

Despite the relief decreasing costs have given the paint industry, the

Three main paint categories break down this way

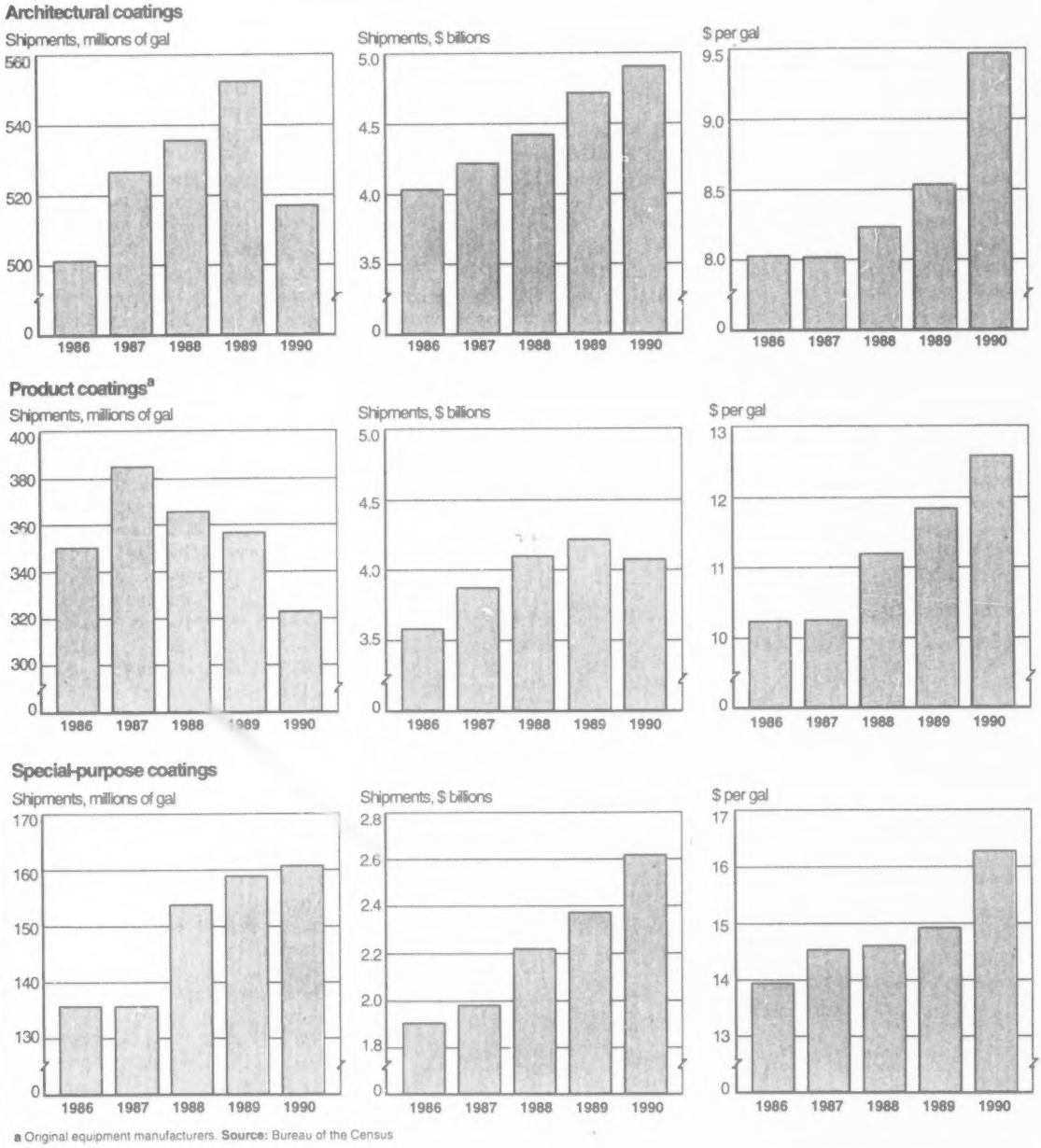
Architectural coatings
- Exterior house paints
- Interior house paints
- Undercoaters, primers & sealers
- Stains

Product coatings[a]
- Wood furniture & fixtures
- Automotive
- Metal containers
- Machinery & equipment
- Factory-finished wood
- Metal furniture & fixtures
- Sheet, strip & coil
- Nonautomotive transportation
- Appliances
- Electrical insulation
- Marine
- Film, paper & foil
- Pipe
- Toys & sporting goods
- Miscellaneous consumer & industrial products

Special-purpose coatings
- Automotive & machinery refinishing
- High-performance maintenance
- Traffic paint
- Roof coatings
- Bridge maintenance
- Aerosols
- Swimming pool coatings
- Arts & crafts
- Metallic coatings
- Multicolored coatings

a Original equipment manufacturers. **Source:** SRI International

Shipments up only for special-purpose coatings, but prices rise in all categories



a Original equipment manufacturers. **Source:** Bureau of the Census

recession still has hurt manufacturers. Nalco recently sold its Day-Glo paint business to RPM Inc. of Medina, Ohio, and Ferro and Glidden, a subsidiary of ICI, have formed an alliance in powder coatings. In Europe, DSM is discussing the possibility of swapping its powder-coatings business with Akzo, which would give up its engineering plastics business in the transaction. The transaction, if it takes place, would fill out Akzo's paint portfolio and reinforce its position as one of the largest paint manufacturers worldwide. In another European transaction just completed, Rhône-Poulenc sold its interest in Radcure Specialties, a producer of radiation-curable monomers and oligomers, to the Belgian company UCB. Radcure has substantial U.S. operations managed from its U.S. headquarters in Atlanta.

A 1990 survey of the paint and

coatings industry based on Bureau of Census figures shows that architectural coatings, which include paints applied both to interior and exterior surfaces, made up slightly more than half of all paints shipped in the U.S. Product coatings for the original equipment market, which includes automotive and appliance coatings, account for some 32% of U.S. paint volume. And special-purpose coatings make up the remaining 16% or so of total paint shipments. This category includes large-volume maintenance items, automotive refinishing, and coil coatings.

Shipments of architectural coatings in 1990 declined 6.3% from the previous year to 517 million gal. The value of those shipments, however, rose 4% to $4.91 billion last year, and the unit price per gallon rose 11% to $9.47. The recession, in combination with a continuing lag in new housing starts, did have a negative impact on these coatings. However, shipments of architectural coatings as a percentage of the overall paint market remained the same in both 1990 and 1989, and they even increased over the 51% share these coatings had in 1988 when more gallons were shipped.

Product shipments last year for the original equipment sector fell 9.5% from 1989 to 324 million gal. The value of shipments also declined, slipping 3.8% to $4.08 billion. Unit price per gallon increased 6.3% to $12.59. Despite the actual slowdown in shipments, costs continued to rise in this category. Paint makers sought to recover both the costs of raw material increases in previous years and the costs related to reformulating to meet ever-increasing VOCs limits.

For special-purpose coatings, according to the government figures, 1990 shipments increased 1.3% from 1989 to 161 million gal. The value of those shipments rose 11% to $2.62 billion, and the unit price per gallon increased 9.1% to $16.27. The relatively good performance of this product sector may be attributed to the recession. Plant and equipment idled during the recession is frequently refurbished or maintained for use when the economy picks up again. Also, bridges and other outdoor structures that are overseen by local or federal governments still must receive regular maintenance. Those costs are usually deferred only during a prolonged and severe slowdown when tax receipts fall off precipitously.

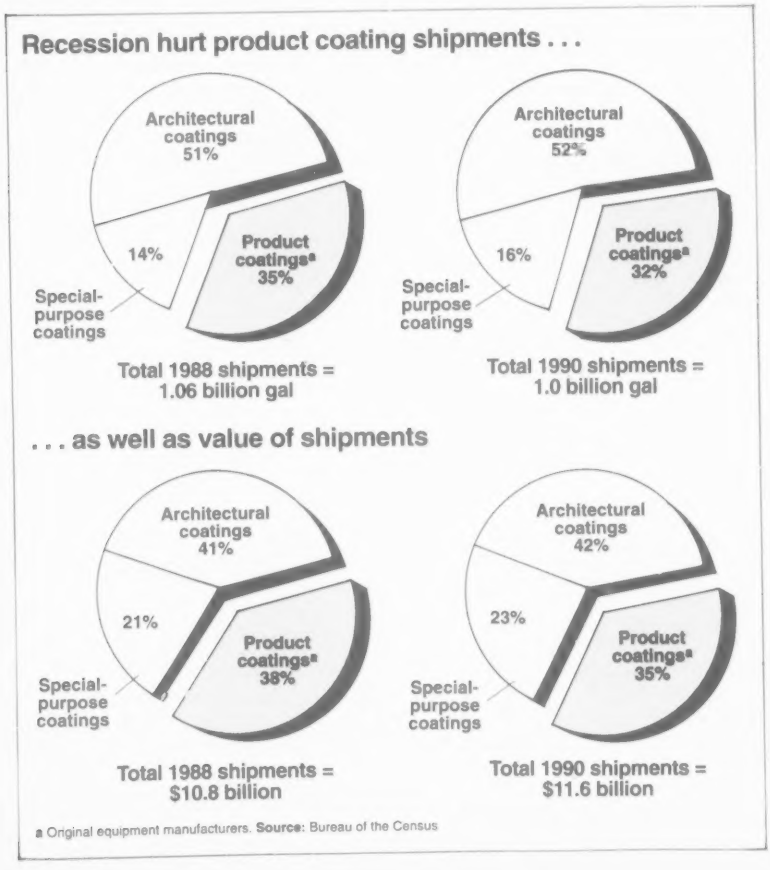
According to the Department of Labor, indexes covering both paint materials and prepared paint prices show radical changes during the first eight months of 1991. In that period, the price index for paint materials declined a surprising 11% to 134.8 (1982 = 100). In 1990 the index rose 5.5% from 1989, following a 12% annual increase in 1989. If the trend for this year continues, 1991 will have been the first year to show a material prices decline since at least 1975.

The Department of Labor's index for prepared paint prices dropped 1.4% in the first eight months of 1991 to an index of 130.1. If this trend is sustained for the year, it also will mark the first year to register a decline since at least 1975.

On an average annual basis, paint material costs increased only 5.8% between 1975 and 1990. Prepared paint prices rose 4.6%. This continues to be an industry that depends overall on factors other than price increases to maintain profitability. Where price increases barely keep pace with inflation, manufacturers continue to survive by gaining market share, buying market share, and improving manufacturing efficiencies.

Whereas the Bureau of the Census reports shipment declines in 1990, the Department of Labor emphasizes the drop in total employment. The number of production and nonproduction paint industry workers declined 1.1% to 61,800 compared with a revised 62,500 for 1989. In 1984, when the industry employed 62,000 people, manufacturers produced 32 million fewer gallons of paint. Productivity for this industry has increased.

The number of nonproduction employees of paint firms declined



4.4% in 1990 to 30,500; production employees decreased 1.1% to 31,300. Between 1981 and 1990, employment of production employees was unchanged. The level of nonproduction employees during the same period of time declined 5%.

Radiation-curable coatings poised for growth

Coatings that are cured almost instantly upon exposure to either electron beam (EB) or ultraviolet (UV) radiation are poised for growth in the world market. They offer a number of advantages in addition to rapid cure rate on assembly lines. The radiation equipment required takes up considerably less space than curing ovens and can coat heat-sensitive materials. The result is, in many cases, 100% solids VOC-free coatings. Costs of these coatings tend to be competitive with other paint systems at $15 to $100 a gal.

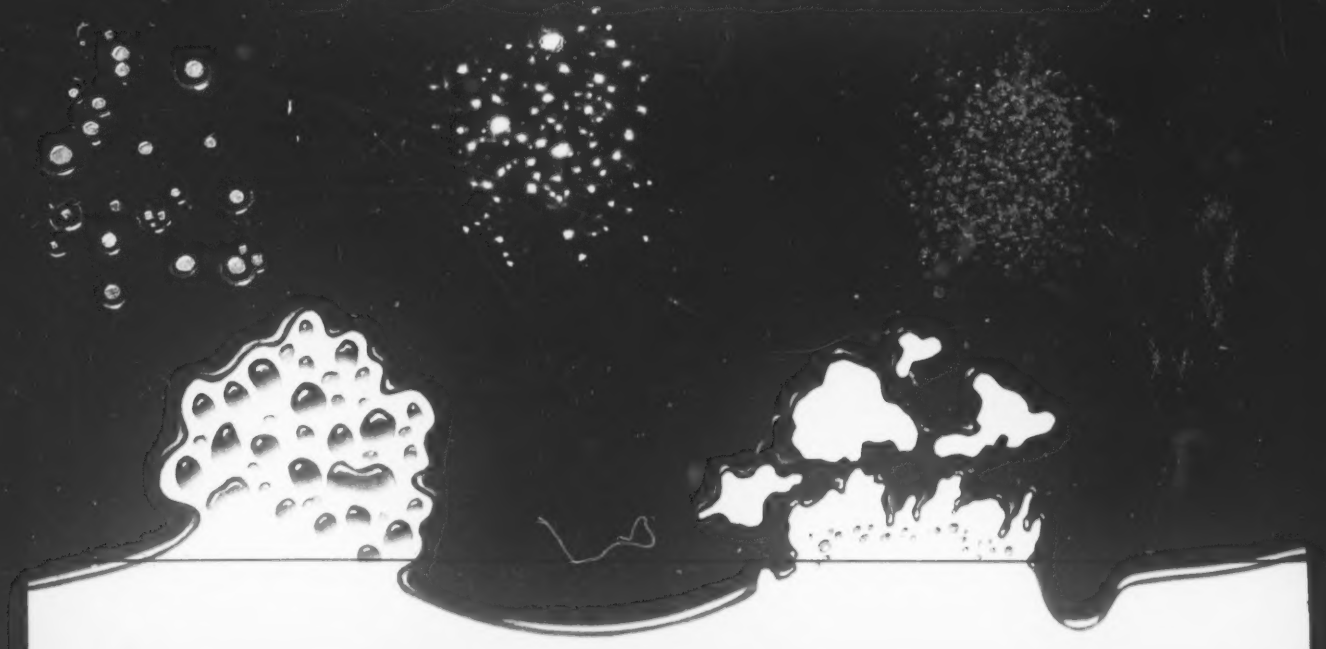
The term "radiation curing" may cause some misunderstanding. It does not mean that coated materials are exposed to radioactive emissions. It does, however, mean that the photons that UV light generates or accelerated electrons from an EB processor can initiate cure in these specially formulated coatings.

Suppliers to the U.S. market estimate the growth rate of radiation-curable coatings at 10 to 15% a year. According to estimates published by consultants Anthony Berejka of Ionicorp, Cold Spring Harbor, N.Y., and William Radak, R&D Coatings, Wexford, Pa., the value of radiation-curable coatings was $110 million in 1989. Their estimates, published in *RadTech Report*, the journal of Radtech International North America, a Northbrook, Ill.-based trade association for radiation technology, break down principal applications by plastics, the largest use, followed by wood, paper, metal, and miscellaneous. The two consultants estimate the market at $250 million for all radiation-curable material uses including coatings, electronics, inks, and adhesives.

Rauch Associates also estimates the size of the market at $250 million, with 10 million gal of coatings without solvents shipped in 1989. Rauch cites major uses on flatstock-fillers in particle board and hardwood flooring, protective coatings for cans, high-gloss no-wax coatings for floor tiles, and wood finishes. Like powder coatings, radiation-curable coatings offer paint applicators for the original equipment market a new technology to both speed up processing and reduce waste and VOC output. Unlike powder coatings, with sales in excess of 100 million lb annually (C&EN, Sept. 17, 1990, page 58), radiation-curable coatings are only beginning to establish themselves in the market now, though they have been under development for at least two decades.

Ionicorp's Berejka, who is also president of Radtech, believes that radiation curing of wood and plastic

Problems.



Fusion Systems technician monitors plastic bottles entering UV curing chamber

coatings offers a way around the VOC issue. Adoption of UV and EB curing systems allows compliance with the 1990 Clean Air Act without the investment in solvent recovery systems, says Berejka. And since radiation cures without high-temperature exposure, it is ideal for curing plastic components. The technology is not cheaper, he says, just more cost-effective. Where unit sales are concerned, radiation-curable coatings are high cost because they are still low-volume materials. Berejka sees prices coming down as volume increases.

R&D Coating's Don Eshenbaugh says sales of radiation-curable coatings began in the mid-1980s, though development of systems for inks and coated printing stock in graphic arts began in the early 1970s. He predicts that with all the interest in radiation-curable coatings now, a sharp upturn in their growth will occur beginning in 1995. Though most users think of radiation-cur-

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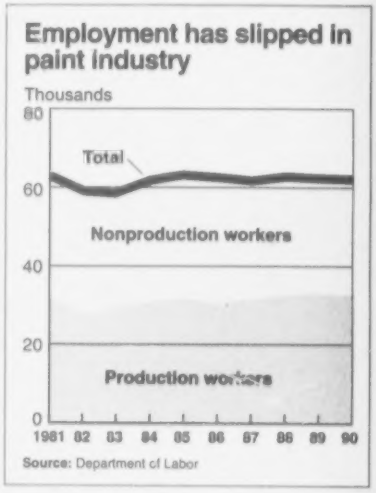
able coatings as primarily suitable for production line coatings of flat stock, curing of three-dimensional objects is possible. Properly designed equipment can expose all parts of a product to light, he notes.

According to Bob Sweetman, engineering director for Fusion Systems, a privately held manufacturer of UV lamp systems in Rockville, Md., the push to lower VOC emissions has motivated much of the switch to radiation-curable coatings. Sweetman describes his company as a market leader in the manufacture and sale of UV equipment. Fusion Systems invented and developed long-life electrodeless lamps that will outlast traditional tungsten arc lamps, he says.

Fusion takes a modular approach to the lamp systems it assembles for its customers, says Sweetman. The company assembles lamp modules to suit customers' process requirements. Startup costs for UV systems range from $4200 to $200,000 for the largest system. That contrasts with EB curing systems that cost anywhere from $750,000 to $1 million, says Sweetman. Electron beam curing is justifiable only when very high speed systems are required or when UV beams cannot penetrate. Electron beam systems are also frequently installed when nitrogen atmospheres are required for a more complete cure. That inevitably adds to the cost of the system as well.

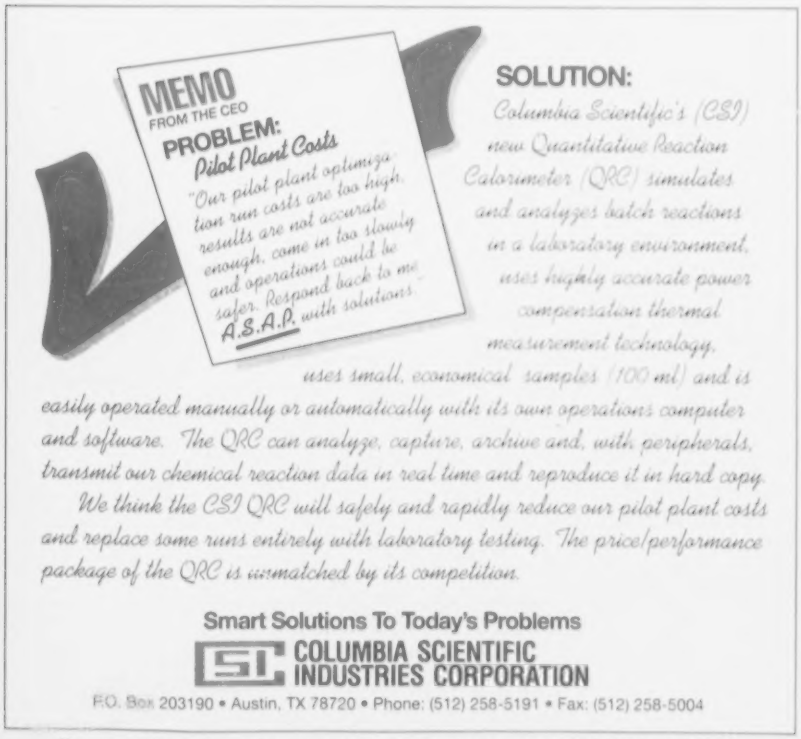
UV systems now can cure pigmented coatings. In the past, mercury vapor arc lamps could not cure pigmented coatings because they only produced UV light at the lower end of the spectrum. Sweetman claims that Fusion Systems' latest lamp system can cure heavily pigmented white coatings up to 200 μm thick on wood substrates. Formerly, only EB systems could cure that type of coating. Still, he cautions, heavily pigmented thick coatings will not cure well under UV light. Although the company's system frequently cures clear coats as thick as 0.1 inch, it will not be able to cure heavily pigmented coatings of the same thickness.



Aetek, another manufacturer of UV lamp systems, estimates that UV systems cost about half of what EB systems cost. Mark Gilmour, sales representative for Aetek, Plainfield, Ill., says heavily pigmented coatings often cure better with EBs. In some wood applications, Aetek may install its lamps in a line with another manufacturer's EB equipment. In these hybrid systems, UV will help the coating to "flow out" while the EBs bring the coating to a full cure, says Gilmour.

Flat materials and rotating convex surfaces cure best because they can be directly exposed to sources of UV light. Aetek claims clear coats exposed to a lamp delivering 400 watts per inch can cure plastics at a rate of 300 feet per minute, metal at 200 feet per minute, and wood at 25 feet per minute. In addition to lamp lines for decorative metal, fiber-optic, and auto lamp reflector coatings, Aetek installs custom wide-lamp lines to cure clear coats on no-wax flooring. Gilmour says the flooring systems require highly specialized lines that, unlike most UV systems, make use of nitrogen atmospheres to exclude oxygen for better finishes.

Where Aetek does install its lamps in a hybrid system, it frequently does so with RPC, Hayward, Calif. RPC, which formerly owned Aetek and which is now majority owned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by Japan-based Sumitomo Heavy Industries, sold its Aetek division to Geo International Corp., Stamford, Conn., in 1988. According to David A. Meskan, vice president of marketing for RPC, UV and EB technologies are really not competitive. They only overlap in a small area. Electron beams, he notes, are superior in penetrating opaque coatings. For instance, on printed wood-grain finish papers, the beams penetrate the top coat, the paper, and the adhesive that laminates the paper to a surface all in one pass.

EB equipment is also much more expensive than UV equipment. A basic EB system costs about $600,000, says Meskan. A big system may approach $2 million, whereas most systems installed today approach $1 million. However, they offer higher productivity and more energy efficiency than either UV cure or more traditional oven-baked cure, claims Meskan. The company's fastest line is installed on a 130-inch-wide web that moves material for cure at 1000 feet per minute, he says. Meskan concedes that UV-curing applications are 50 to 100 times more energy efficient than oven curing. However, EBs cure coatings with an efficiency five to 10 times greater than UV curing, he says.

Other advantages EB curing makes possible are coatings without expensive photoinitiators that are required for UV cures; no-shrink coatings because the 100% solids coatings do not contain solvents that must be evaporated; and EB-cured coatings because they provide good mechanical properties such as high-gloss and good abrasion resistance, says Meskan.

Over the past five years, the biggest push in EB systems has been on web printing presses to cure coated paper stock and printing inks. However, says Meskan, during the past 18 to 24 months, wood furniture makers have become very interested in EB-cured flat stock to speed the production of ready-to-assemble furniture. A few have begun to install EB lines, he says.

U.S. customers, says Meskan, are making greater use of EB systems than their counterparts in either Europe or Japan. Although Europeans may be ahead in the use of UV cure, the U.S. leads in EB technology and installation. And he adds that the U.S. leads Japan in the use of EB equipment. The Japanese are just moving to order EB production equipment at this time.

German-based Henkel has headquartered its radiation-curable materials business in the U.S. According to Robert Lieberman, a business director for Henkel Coatings & Inks, all new product synthesis and research and development for radiation-curable coatings is based in Ambler, Pa. The company supplies industry formulators with three major components for radiation-curable coatings: low-molecular-weight monomers, oligomers, and photoinitiators. Whereas Henkel manufactures the first two types of components, it has been a nonexclusive distributor for Velsicol Chemical's line of photoinitiators since August. With the conclusion of its distribution agreement with Velsicol, Lieberman says Henkel is now a one-stop shop for radiation curable raw materials.

Lieberman believes the radiation-curable coatings market will grow 10% per year for at least the next five years. In support of that growth, Henkel has introduced a half dozen new monomers within the past year, he says. Most recently, the company has introduced a new line of reactive acrylate monomers to be sold under the Photomer 8000 series tradename. They are methoxy ether acrylates, which yield improved reactivity, film, and adhesion properties compared with other commercially available monofunctional acrylates and are competitively priced, says Lieberman.

Improved reactivity is an important goal at Henkel, he notes. The objective is to come up with material that will cure fully under normal atmospheric conditions. In that case, the inert nitrogen atmospheres that are now often required for cure with EB-curable coatings would be unnecessary. The current line of mono-

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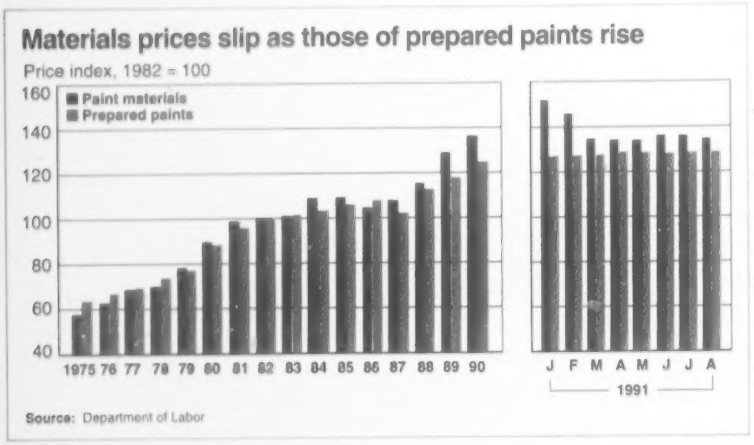


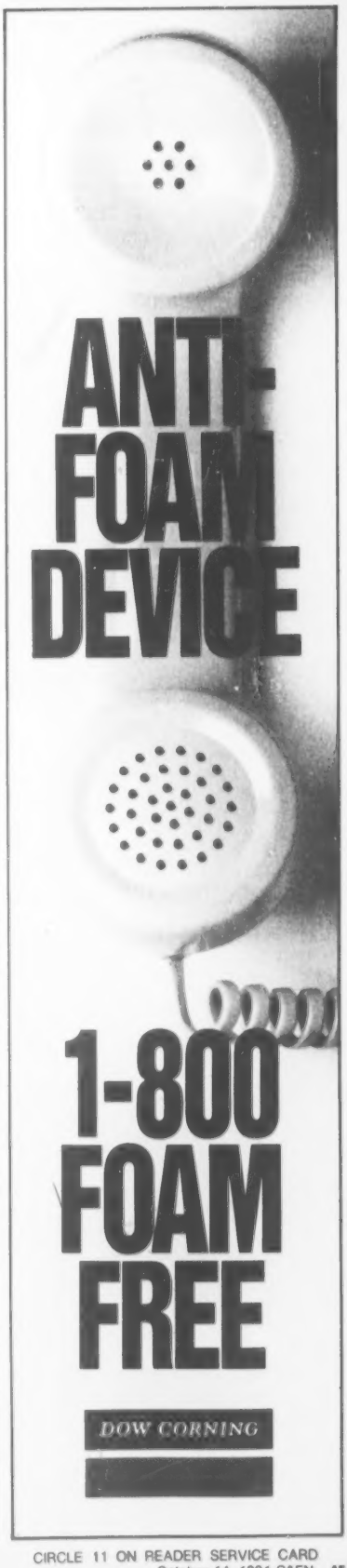
mers and oligomers includes mono-, di-, and trifunctional acrylates; amine acrylates; epoxy acrylates; polyester acrylates; and urethane acrylates.

Lieberman acknowledges concern within the radiation-curable coatings industry over skin and eye irritation caused by acrylate materials. In 1987 suppliers and users teamed up to organize the Specialty Acrylates/Methacrylates Panel (SAMP) under the Chemical Self-Funded Advocacy & Research Division of the Chemical Manufacturers Association to test the toxicity of the acrylates, he points out. Additionally, Henkel is developing nonacrylate backbones for its line of monomers and oligomers to remove concern over acrylate toxicity. However, none are yet commercially available, he says.

According to SAMP manager Marian Stanley, the group has started a voluntary research program testing acrylates and methacrylates to gain knowledge and toxicity information about the materials. These are not strictly radiation-curable materials, but include those with other uses. Companies funding the program include Hüls, 3M, Rohm & Haas, Du Pont, Dow Chemical, PPG, Union Carbide, and Lubrizol. Although the group hopes to show lower toxicity for the materials than is now believed, not enough testing has been done to date to prove that assertion, says Stanley.

Paul C. Nelson, manager of environmental health and safety affairs for Radcure Specialties, Atlanta, and first chairman of SAMP, says the panel was formed to resolve issues surrounding Environmental Protection Agency regulations affecting the introduction of acrylates into the market. The materials are suspected skin carcinogens, he says. Test programs now under way in consultation with EPA are meant to evaluate current regulations. A preliminary benefit of testing already completed was EPA's agreement to modify use rules for low-molecular-weight acrylates. As a result, labeling on material safety data sheets has been revised "more in line with what you'd expect under OSHA regulations," says Nelson. Still, all manufacturers of these materials recommend that people working with them wear safety glasses or eye goggles and impervious gloves to avoid all eye and skin contact, he says.

International Specialty Products (ISP), Wayne, N.J., once known as GAF Chemicals but now a publicly traded company, has developed a family of radiation-curable materials without the toxicity problems associated with acrylates. Three vinyl ethers that have low-toxicity profiles have been introduced to the market under the Rapi-Cure tradename, according to Jeff Plotkin, ISP market manager. Two of the vinyl ethers, one a triethylene glycol divinyl ether and the other a cyclohexanedimethanol divinyl ether, are difunctional reactive diluents that can be used in place of acrylates, he says. The third one, a hydroxybutyl vinyl ether, can be used either as a reactive diluent or as an intermediate to produce vinyl ether-containing oligomers.



Plotkin says ISP is working on a range of mono-, di-, and trifunctional vinyl ethers to allow formulators more latitude. The main advantage of vinyl ethers is that they offer formulating versatility, he says. Because of their solvating properties, ISP is hoping to develop sprayable wood coatings approaching 100% solids. This advance will allow furniture makers to spray intricately designed furniture with low or no VOCs. Of course, these advances do carry a higher price tag. Plotkin says that vinyl ether-containing systems will cost 10 to 15% more than comparable acrylate systems.

According to Jim Reese, vice president of marketing for DSM Desotech, Elgin, Ill., the vinyl ethers are safer to handle than the acrylates since they are less likely to be skin sensitizers. Some of the vinyl ethers are not even eye irritants. In addition, they are low odor materials, unlike the acrylates whose odor can be offensive, he notes. DSM Desotech uses GAF's vinyl ethers to manufacture vinyl ether maleates, which are sold to paint formulators. The company, formerly owned by DeSoto but now owned by Dutch chemical company DSM, also manufactures acrylate oligomers. Reese says the company's Desolite and Cableite materials dominate the market for telecommunications resin systems.

The market for radiation-curable materials, Reese adds, has grown 12 to 15% annually over the past five years, though some markets, such as telecommunications optical fiber and cable coatings, have grown faster. He projects yearly growth of 10 to 15% for the radiation-curables market over the next five years, particularly in markets for which the low- or no-solvent characteristics of the technology offer a benefit. He sees promising growth in the market for sprayable vinyl ether-modified coatings on wood.

Radcure, a manufacturer of radiation-curable monomers, oligomers, and specialty photoinitiators, offers a variety of acrylate-based systems. The company, says a spokesman, is involved in a number of developmental research projects, but declines to be more specific. Radcure was created as a unit of Celanese and was subsequently bought by RTZ Chemicals. RTZ linked up with Belgium's UCB to further develop radiation-curable monomers and oligomers. Rhône-Poulenc bought RTZ, thereby gaining an interest in what became Radcure in 1989. UCB subsequently operated Radcure and early last month reached an agreement with Rhône-Poulenc to acquire all shares of Radcure, though no financial details have been disclosed.

A major supplier of pigment systems and additives for radiation-curable coatings is Ciba-Geigy. Although it supplies a relatively modest amount of antioxidants, light stabilizers, and optical brighteners for radiation curables, the company's major additives emphasis is photoinitiators for UV-curable coatings. According to Andrew Mar, business director of additives for radiation curing, radiation curable coatings are growing at a rate of 10 to 15% a year in the U.S., 15 to 20% in Japan and Europe (higher, albeit from a lower base). The principal attraction in Japan and Europe is the space savings UV cure systems offer over oven cure lines. In addition, energy costs are higher in Europe and Japan than they are in the U.S., thus giving an additional boost to UV-curable coatings.

Mar believes that another boost to the growth of UV curables will come around 1994 or 1995 when EPA rules affecting VOC emissions from wood and plastic coatings will spur coatings users to convert to a low- or no-VOC alternative like UV-curable coatings. Other alternatives for wood and plastics may be waterborne coatings and high-solids solvent coatings.

In trying to anticipate market needs, Ciba-Geigy has offered a variety of photoinitiators, many developed in concert with lamp manufacturers like Fusion and Aetek as well as monomer and oligomer suppliers, says Mar. Ciba-Geigy introduced its first photoinitiator 16 years ago—Irgacure 651, a 2,2-dimethyl-2-phenyl

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acetophenone that still has broad use, he says. However, because Irgacure 651 is activated by UV radiation that some pigments absorb, Ciba-Geigy has introduced other photoinitiators—such as Irgacure 369, an acetophenone-class photoinitiator—that allows more pigment loading in a coating without cutting down on the UV-induced cure of a coating.

At $39 per lb for Irgacure 369, Mar is aware that the photoinitiator is the most expensive component in a radiation-curing formulation. However, he notes, the manufacture of Irgacure 369 requires a seven-step synthesis and, although it is incorporated into a coatings formulation at 1 to 3% by weight, it is not quite so expensive on a unit basis and offers good value. In fact, UV cure would be impossible without the use of a photoinitiator, he points out.

Ciba-Giegy's most recent photoinitiator is its Irgacure 784, a titanocene photoinitiator that absorbs longer wavelength light. As a result, the UV source can be designed so that it poses less danger for eye damage, says Mar. Another recent introduction is Irgacure 261, a ferrocene-based photoinitiator recommended for epoxy ethers only. Mar says it is Ciba-Geigy's first cationic photoinitiator. (Cationic photoinitiator competitors include 3M and Carbide.)

Borden, a formulator of radiation-curable coatings, sees double-digit growth ahead, says Camille J. Kallendorf, commercial development manager for Borden's packaging and industrial products division. Emerging growth areas in particular are coatings for plastics, automotive components, and stereo lithography. The latter is a system developed to manufacture three-dimensional computer-controlled models using UV-cured material. The system allows engineers to make parts prototypes.

Kallendorf says Borden custom-manufactures two basic types of systems for the market—acrylates and epoxy cationics. Although she acknowledges that the acrylate systems are skin sensitizers, the problem is not so significant now as it once was. Formulators, she says, have come up with less irritating formulations, and industry practices in handling have been improved. The epoxy cationic curing systems, she says, are easily handled and are not significant skin sensitizers.

Leigh Quinn Jr., vice president of sales for QureTech, a Seabrook, N.H., division of paint resin maker K. J. Quinn, says the radiation-curable coatings are reliable because once the system is put into place, it works regardless of moisture in the air or other environmental variables. Once the formulation is set, and the radiation source is in place, maintenance is minimal. A production line can start up at the same performance level at which it was shut down, he says.

QureTech supplies fully formulated 100%-solids, specialty UV- and EB-curable acrylate coatings. They are custom designed to fit a manufacturer's requirements, and, in doing so, QureTech works closely with radiation source suppliers. Many materials suppliers and formulators are predicting rapid growth over the next few years, but Quinn is cautious. He expects mixed results for radiation-curable coatings over the next few years because of the current weak economy. Still, he agrees that radiation-curable coatings opportunities exist and in the long run will grow.

Isocyanate capacity grows as do coatings uses

Whereas radiation-curable coatings offer performance advantages on production lines, isocyanate-containing coatings make for more durable, abrasion-resistant paints and coatings. Systems that incorporate aliphatic isocyanates also offer good weatherability and are in increasing demand for such exterior applications as bridges, storage tanks, and process industry plants where outstanding chemical resistance is a requirement.

The number of aliphatic isocyanate suppliers has grown over the past few years in response to the demand for systems incorporating aliphatic isocyanates. Both Hüls and

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clude powder coatings and UV-curing resins, notes Cullen. For UV-curing systems, the isocyanate is incorporated as part of an oligomer or other resinous material, giving the resultant UV-cured system good performance characteristics. In particular, the urethane linkage gives excellent abrasion resistance, a reason, says Cullen, for its use in UV-cured hardwood floor clear coats.

Hüls will soon complete the construction of an isophorone diisocyanate (IPDI) unit as part of a larger $100 million project at its plant near Mobile, Ala. Until now, Hüls had been supplying customers with IPDI imported from its facility in Germany. According to Henry A. Kasprzak, general manager of the coatings raw material group at Hüls, the Mobile plant probably will be on stream during the first quarter of 1992. Though he declines to say what the unit's IPDI capacity will be, he comments that "availability will not be a problem" once the plant begins regular production.

Along with the domestic production of IPDI and derivative polyisocyanates, Kasprzak says Hüls is prepared to offer coatings manufacturers more extensive coatings support from recently enlarged labs in the company's Piscataway, N.J., technical center for liquid coatings and in Mobile for powder coatings. IPDI, adds Kasprzak, is particularly suited for use in VOC-compliant coatings because of the low viscosity of the material.

Kasprzak believes that overall growth of the aliphatic isocyanates market is 8% per year, with faster growth of 10% annually for isocyanate-containing powder coatings. These figures may not be as reliable for 1991, because the economy has slowed somewhat this year, he says. Hüls sells its IPDI-derived materials under the names of Vestnat for the monomer and Vesticoat for the trimer and converted products.

Though the isocyanate-containing materials offer excellent performance characteristics, Kasprzak notes that isocyanates are hazardous materials. Hüls supplies a great deal of information to customers on the safe use and handling of its materials, as do other isocyanate producers. However, he notes that because IPDI is not as volatile as some other isocyanates, it is easier to handle than they are.

Olin also plans to start up a new aliphatic isocyanates plant in Lake Charles, La. According to Tony Hamer, general manager of the performance urethanes business, the new plant probably will be completed by Feb. 1. The company expects to begin shipments of product during the second quarter, but not all products will be available immediately, he says.

Plant capacity hasn't been disclosed, though it is a "multiproduct unit" whose ultimate capacity will depend on the product mix of HDI, IPDI, and hydrogenated MDI to be produced at the site. Cost of the new unit also has not been revealed. Customers are receiving development quantities from a pilot plant also located in Lake Charles, he says.

Olin sees itself as an alternate supplier able to give formulators a choice: Olin or Hüls for IPDI, Olin or Mobay for hydrogenated MDI and HDI. Hamer notes that Olin also sells an aromatic isocyanate, toluene diisocyanate (TDI). It has many uses such as in foam products, but may also be used in coatings such as on interior wood where light stability is not an important asset, he says.

Spurring use of aliphatic isocyanates is the fact that the urethane formulas in which they are a component can be made into high-solids coatings and thus are low in VOCs. Hamer sees opportunities for Olin's aliphatic isocyanates in both the coatings and elastomers markets. He says the new plant coming on stream in Lake Charles is similar to the Mobay and Hüls units, but that Olin's labs are working to bring products on stream that will be unique, differentiated products.

"Our approach will be to work with customers and customize formulations for them," he says. As for its raw material, Olin will supply Du Pont with diamines. Hamer notes

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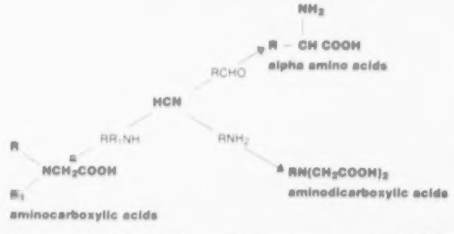

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that Du Pont and Olin have traditionally had a close working relationship. Du Pont is also a major user of aliphatic isocyanates in the coatings it supplies to the automotive and maintenance coatings market, he notes. W. R. Grace will be Olin's source for nitrile ingredients, and isophorone is available on the merchant market. Olin will offer customers applications and technical service help from its research facility in Cheshire, Conn., he adds.

American Cyanamid opened a commercial facility to produce *m*-tetramethyl xylylene diisocyanate (TMXDI) and dimethyl *m*-isopropenyl benzyl isocyanate (TMI) in late 1987. Capacity figures for the unit have not been disclosed, says Jim Druzbacky, coatings business manager for the urethane chemicals department.

Druzbacky says the Cyanamid products are doing well in the market as relative newcomers. He does not expect them to compete head to head with the other aliphatic isocyanates, because Cyanamid believes they are specialty isocyanates that will fit in high-performance niches. They are not "me too drop-ins for IPDI or MDI," says Druzbacky. He adds that "we are looking for value-added niches where our products can command a higher price for their performance characteristics." Those include automotive and other original equipment markets, auto refinishing markets, and maintenance coatings, plastic coatings, and industrial metal coatings.

TMXDI has just been introduced in a water-based urethane dispersion under the Cydrothane tradename, he says. Cydrothane can be formulated into a coating with good film properties, hardness, toughness, and 0.1 lb-per-gal VOC content, without the use of organic cosolvents, Druzbacky says. Another Cyanamid polyisocyanate resin, Cythane 3160 based on TMXDI, is aimed at automotive coatings as well as plastic, coil, and electrodeposition coatings, where the flexibility and toughness the material offers is an advantage.

Druzbacky says that TMXDI-based materials also offer minimal safety risks. Tests to date show that such materials are not pulmonary sensitizers, says Druzbacky, though studies to determine toxicity are still ongoing. Cyanamid still recommends that the materials be treated as hazardous and recommends that skin contact be avoided and users wear respirators.

Industrial maintenance coatings flat in 1991

Aliphatic isocyanates are a major component in high-performance maintenance coatings, and may help refuel a resurgence in this steady but rather dormant market. According to Jay Willner, a consultant in San Francisco with WEH Corp., sales of maintenance coatings amount to about $1 billion annually. About 45 million gal of paints go into this market, which includes coatings for petrochemical and petroleum plants, water and waste treatment plants, electric and gas utilities, bridges and highways, offshore oil and gas platforms, aircraft, and farms.

Willner characterizes 1990 as a relatively good year, but he finds that 1991 is not turning out so well. A bright spot over the next five years, however, is expected to be coatings to maintain structures that contain leaks around storage containers. He projects that that market, valued at $80 million in 1991, will grow 10% per year to $130 million by 1996.

Formulators in the maintenance market number more than 100 with the 10 largest suppliers holding 71% of the market in 1990, up from 55% in 1984, and the five largest holding 46%, up from 34%. Following the consolidations of the past few years that include the ICI purchase of Glidden, Valspar's purchase of Mobil's paint business, and Courtaulds' purchase of Porter Paints, Willner doesn't expect this industry to concentrate further. Any large company that purchases any of the numerous small specialists in the business would only add between $2 million and $5 million in sales to its portfolio, says Willner.

According to Jack J. Bracco, coatings division market development manager at Mobay, the push to lower VOC limits also has affected this market. With government rules lowering VOC limits to 2.8 lb per gal in 1994, Mobay has come out with lower viscosity acrylic polyols to meet the market's needs, he says. Research in polyol technology along with work on waterborne polyurethane dispersions probably will allow isocyanate-containing coatings to maintain their edge over alkyds, Bracco believes.

Mobay photo

Worker applies high-performance polyurethane coating to steel tank

Bracco is worried that as allowable VOC contents are pushed lower, coatings may not perform so well. A problem with one-component waterborne polyurethane dispersions is that they are difficult to apply under very humid conditions and in inclement weather like all waterborne systems. The question now is, he says, "How low can we go in VOCs with polyurethane dispersions and still get good performance?" Coatings usually fail because they are improperly mixed or applied over frost, dirt, or grease. Higher solvent-containing coatings give a margin of latitude, but waterborne coatings require "supercritical clean surfaces to get good adhesion," he says.

To get those supercritical clean surfaces will require blasting of structures, and removal of the old paint, greases, and oils that will pose more than just a simple disposal headache. Blasting will loosen much old lead paint that will have to be removed carefully and disposed of properly. Current polyurethane coat-

ings systems may cover the lead paints and put off, at least for now, the disposal of the old lead-containing coatings, he says. Where removal of lead paint can be postponed, Bracco recommends a moisture-cured polyurethane spot primer containing Desmodur E-21, followed by a two-component aliphatic polyurethane intermediate and top coat over the entire structure.

Du Pont's Maintenance Paint Service (MPS) tries not to remove lead-containing coatings unless they are about to fail, says James T. Kimball, director of maintenance finishes. Du Pont's current line of coatings, including urethanes, epoxies, and alkyds, are heavy metal-free, he says. MPS prefers to do spot repairs where lead coatings may be failing so as to lower the annual costs to its customers, whose facilities include petrochemical and refining plants as well as some bridges. It formulates coatings based on it own raw materials as well as materials it buys from outside suppliers.

In maintaining a customer's facility, Du Pont prefers to brush and roll on coatings rather than spray coating to reduce exposure to the applicator as well as plant workers nearby. It is also developing isocyanate-free coatings that promise the same performance as isocyanate-containing coatings, says Kimball. It recently developed a new medium solids resin system based on polyacryl anhydride that it believes will perform as well as urethane coatings.

Because worker safety in applying coatings on maintenance structures is an issue, and because of the critical preparation necessary for repainting any large steel structure, the Steel Structure Painting Council (SSPC), Pittsburgh, Pa., has set up a certification program for applications contractors. The nonprofit organization has 650 individual and 400 company members from businesses including painting contractors, facility owners, coatings manufacturers and distributors, applications equipment suppliers, and industrial hygienists.

Bernard R. Appleman, SSPC executive director, says that his group is working to "professionalize" the industrial coatings industry. One step in that direction has been a paint contractors certification program that evaluates the contractor against the SSPC's safety, quality control, technical capability, and management procedures standards. SSPC hires an independent evaluator who does a thorough inspection, including field inspection of a contractor, says Appleman. The contractor pays for the evaluation. SSPC certifies those who get a passing grade. The program requires annual reevaluation in areas in which the contractor may have been weak, says Appleman.

Of the 1500 or more contractors performing industrial painting of steel structure in the U.S., Appleman says his program has certified about 23. He hopes more will enter the program in time. SSPC is encouraging facility owners to require that contractors have certification before they are allowed to bid on a project, he says. "It is important not to go just for the lowest bid, but for the lowest qualified bid." Appleman believes that some facility owners do not monitor the safety of their contractors as closely as they monitor their own personnel. This certification program will go the extra step in ensuring that at least painting contractors will handle their job according to safe procedures.

Appleman thinks suppliers of two-component urethane systems have done a good job of communicating relative risks of applying isocyanate-containing coatings. A few facility owners have refrained from using two-component systems because they have a no-risk mentality, he says. "I don't think you can operate with no risk." He does applaud the greater general awareness of safety issues, however, and cautions that the industry will have to pay greater attention to dealing properly with lead paint removal in preparation for repainting.

Not all structures that need maintenance are constructed of steel. Concrete can degrade under exposure to harsh environments. Texaco Chemical, Houston, Tex., says it has

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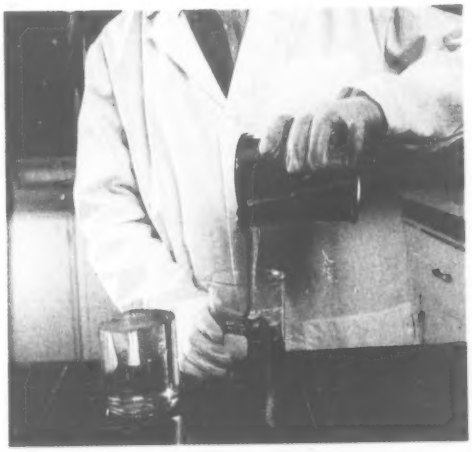

Ciba-Geigy Irgacure 369 acetophenone-class photoinitiator, here being poured into beaker as liquid, can be cured into solid block

a solution. According to Rodney F. Lloyd, manager of market development for the performance chemicals business, the company's Jeffamine polyoxypropylene amines in combination with either aromatic isocyanates, MDI, or TDI, produce a concrete stabilizer that gels in two to three seconds and is tack free in 10 to 15 seconds.

The system can be applied inside manholes and can be used to protect the inside of sewage pipes from hydrogen sulfide breakdown. This polyurea system will not foam on damp surfaces the way polyurethane systems will, notes Lloyd. It provides good mechanical adhesion without pinholes, though Lloyd says it is not the most attractive looking coating. It has an "orange peel" surface because of its rapid cure. "But most users don't care what it looks like," he says, because it is generally used out of sight. Other applications Lloyd suggests for the material is as a seamless lining for man-made ponds where it is applied over a ground stabilizing fabric. Further work is under way to improve adhesion of the material to metal. Lloyd says that Texaco's Austin lab is willing to work with customers to develop applications for the polyurea systems.

Mobay's Cullen believes that the combination of Mobay's isocyanates with Texaco's Jeffamine polyurea chemistry is a potential growth area for both companies. He says many trial applications are under way with the material and thinks it looks most promising for uses on concrete.

Dow Chemical's M. Anthony Johnson, market manager for industrial coatings, says Dow's aromatic isocyanates are used in industrial maintenance coatings when weatherability is not a factor. He estimates that 56% of isocyanates used in industrial maintenance are aromatic isocyanates. Dow is a major supplier of MDI for maintenance coating primers as well as in electrodeposition coatings for automotive uses. He projects growth of the maintenance coatings market at 3% annually.

Dow supplies the maintenance coatings market with liquid epoxy resins, liquid epoxy novalacs, and solvent-blended epoxy resins. These materials may be used as primers, midcoats, and top coats. Where weatherability is a factor, Johnson says that applicators typically use an aliphatic-containing isocyanate coating. To supply the market with a low-VOC resin, Dow has recently introduced DER 362, the company's first low-viscosity, low solvent-containing epoxy resin with good formulations latitude, he says.

According to Glidden's William F. Ashmore, manager of industrial maintenance sales, two-component urethane paint systems make up 40% of the maintenance market. Glidden recently introduced an acrylic-urethane coating system and expects to introduce a lower cost similar coating soon.

Ashmore says that Glidden's Rustmaster Pro is a water-reducible vinyl coating system that gives performance similar to inorganic zinc-epoxy primers followed by urethane top coats. The Rustmaster primer produces a chemical reaction on steel surfaces creating a pyroaurite protective surface. A three-coat system provides low oxygen and moisture permeability. The system has a low VOC content—0.5 lb per gal—and is selling in Florida, with approval pending in Pennsylvania and testing under way in Michigan, says Ashmore. □